

We claim:

- 1 1. A process for determining at least one candidate spectral endmember that
- 2 represents a group of N spectra comprising:
 - 3 building an initial endmember set composed of at least a first and a second
 - 4 spectrum representing at least a first and a second spectral characteristic expected to be in
 - 5 the group of N spectra;
 - 6 unmixing the N spectra within the group of N spectra to determine what portion,
 - 7 if any, of each of the N spectra match at least one of the at least a first and second
 - 8 spectrum;
 - 9 calculating a first metric value for each of the N spectra, wherein the first metric
 - 10 value accounts for a remaining portion of each of the N spectra not matching the at least a
 - 11 first and second spectrum;
 - 12 defining a metric value range, wherein the N spectra having first metric values
 - 13 within the metric value range are defined as M spectra;
 - 14 ordering the M spectra from highest first metric value to lowest first metric value;
 - 15 comparing each of the M spectra, beginning with the M spectra having the highest
 - 16 first metric value, to each of the N spectra, to determine the frequency with which each of
 - 17 the M spectra occurs within the N spectra; and
 - 18 calculating a second metric value for each of the M spectra, wherein the second
 - 19 metric value combines the frequency of occurrence of each of the M spectra within the N
 - 20 spectra with a first metric value for each of the M spectra, wherein the M spectra having
 - 21 the largest second metric value is the at least one candidate endmember.

1 2. The process according to claim 1, wherein the at least a first and a second spectra
2 are selected from the group consisting of vegetation, shade, soil, and nonphotosynthetic
3 vegetation.

1 3. The process according to claim 1, wherein the step of calculating a first metric for
2 each of the N spectra includes defining an error value for each of the N spectra as the
3 component not matching a combination of the at least a first and second spectrum.

1 4. A process for determining at least one candidate spectral endmember that
2 represents a group of N spectra comprising:
3 building an initial endmember set composed of at least a first and a second
4 spectrum representing at least a first and a second spectral characteristic expected to be in
5 the group of N spectra;

6 unmixing the N spectra within the group of spectra to determine what portion, if
7 any, of each of the N spectra match at least one of the at least a first and a second
8 spectrum;

9 defining an error value for each of the N spectra, wherein the error value is the
10 portion of each of the N spectra that does not match a combination of the at least a first
11 and a second spectrum;

12 comparing the error value for each of the N spectra to a predetermined error value
13 range, wherein spectra having error values within the predetermined error value range are
14 defined as M spectra;

15 ordering the M spectra from highest error value to lowest error value;

16 comparing each of the M spectra, beginning with the M spectra having the highest
17 error value, to each of the N spectra, to determine the frequency with which each of the
18 M spectra occurs within the N spectra; and

19 calculating a metric for each of the M spectra, wherein the metric combines the
20 frequency of occurrence of each of the M spectra within the N spectra with an error value
21 for each of the M spectra, wherein the M spectra having the largest metric is the at least
22 one candidate endmember.

1 5. The process according to claim 4, wherein the at least a first and a second
2 spectrum are selected from the group consisting of vegetation, shade, soil, and
3 nonphotosynthetic vegetation.

1 6. The process according to claim 4, wherein each error value corresponds to a
2 residual spectra and the residual spectra in combination form a residual spectrum of the N
3 pixels.

1 7. The process according to claim 6, further comprising calculating a root mean
2 square (RMS) error value for each of the N pixels by combining the error values for the
3 residual spectrum.

1 8. The process according to claim 7, wherein the step of comparing the error value
2 for each of the N spectra to a predetermined error value range, wherein spectra having
3 error values within the predetermined error value range are defined as M spectra
4 includes:

5 determining an acceptable range of deviation from the mean RMS error;

6 comparing each of the RMS error values for each of the N pixels to the acceptable
 7 range of deviation from the mean RMS error and keeping the M pixels that are within the
 8 acceptable range.

1 9. The process according to claim 8, wherein the step of calculating a metric for
 2 each of the M spectra includes solving the following equations, wherein K_x represents
 3 each of the M spectra, from $x = 1$ to $x =$ an upper limit, $RMSval(K_x)$ is the RMS error
 4 value for the corresponding M pixel, $RMSval(min)$ is the minimum RMS error value for
 5 the M spectra, $RMSval(max)$ is the maximum RMS error value for the M spectra,
 6 $RMSfreq(K_x)$ is the value corresponding to the number of N pixels that match the
 7 residual spectrum for the corresponding RMS error value for the M pixel, $RMSfreq(min)$
 8 is the number of occurrences of the least frequently occurring residual spectrum from the
 9 M pixel residual spectra, and $RMSfreq(max)$ is the number of occurrences of the most
 10 frequently occurring residual spectrum from the M pixel residual spectra,

$$\begin{aligned} 11 \quad & \\ 12 \quad & Normval(K_x) = \frac{RMSval(K_x) - RMSval(min)}{RMSval(max) - RMSval(min)} \\ 13 \quad & \\ 14 \quad & \\ 15 \quad & \\ 16 \quad & Normfreq(K_x) = \frac{RMSfreq(K_x) - RMSfreq(min)}{RMSfreq(max) - RMSfreq(min)} \\ 17 \quad & \\ 18 \quad & \\ 19 \quad & \\ 20 \quad & wgtfactor(K_x) = \sqrt{Normval(K_x) * Normfreq(K_x)}. \\ 21 \quad & \end{aligned}$$

1 10. A process for determining at least one candidate spectral endmember within a
 2 scene having N pixels using scene spectral data comprising:
 3 building a first endmember, wherein the first endmember represents a first
 4 spectral characteristic expected to be in the scene;

5 building a second endmember for the scene, wherein the second endmember
6 represents a second spectral characteristic expected to be in the scene;
7 unmixing the N pixels in the scene to determine what portions of each of the N
8 pixels match at least one of the first and second endmembers;
9 defining a remaining portion for each of the N pixels not matching a combination
10 of the first and second endmembers as an error value, wherein each error value
11 corresponds to a residual spectra and the residual spectra in combination form a residual
12 spectrum of the N pixels;
13 calculating a root mean square (RMS) error for the N pixels by combining the
14 error values for the residual spectra;
15 determining an acceptable range of deviation from the mean RMS error;
16 comparing each of the RMS error values for each of the N pixels to the acceptable
17 range of deviation from the mean RMS error and keeping the M pixels that are within the
18 acceptable range of deviation;
19 ordering the M pixels from highest RMS error value to lowest RMS error value;
20 comparing the corresponding residual spectra of the M pixels, beginning with the
21 M pixel having the highest RMS error value, to the residual spectrum comprising the
22 residual spectrum for the N pixels, to determine the frequency with which each of the
23 corresponding residual spectra of the M pixels occurs within the residual spectra for the
24 N pixels; and
25 calculating a weighting factor for each of the M pixels, wherein the M pixel
26 having the largest weighting factor is the at least one candidate endmember.

- 1 1. The process according to claim 10, wherein the first endmember is a shade
2 endmember and further wherein the shade endmember is determined by a pre-selected
3 baseline percentage of reflectance.
- 1 12. The process according to claim 11, wherein the second endmember is a vegetation
2 endmember and further wherein the vegetation endmember is determined by comparing
3 scene spectral data for the N pixels to a known set of vegetation spectra.
- 1 13. The process according to claim 11, wherein the second endmember is a soil
2 endmember and further wherein the soil endmember is determined by comparing scene
3 spectral data for the N pixels to a known set of soil spectra.
- 1 14. The process according to claim 11, wherein the second endmember is a
2 nonphotosynthetic vegetation endmember and further wherein the nonphotosynthetic
3 vegetation endmember set is determined by comparing scene spectral data for the N
4 pixels to a known set of nonphotosynthetic vegetation spectra.
- 1 15. The process according to claim 12, wherein the step of comparing the scene
2 spectral data for the N pixels to a known spectral data utilizes at least one spectral
3 mapping algorithm.
- 1 16. The process according to claim 10, wherein the predetermined number of Z pixels
2 is at most 500.
- 1 17. The process according to claim 10, wherein the step of calculating a weighting
2 factor for each of the predetermined number of M pixels includes solving the following
3 equations, wherein K_x represents each of the predetermined number of M pixels, from $x =$
4 1 to $x =$ an upper limit, $RMSval(K_x)$ is the RMS error value for the corresponding M
5 pixel, $RMSval(min)$ is the minimum RMS error value for the M spectra, $RMSval(max)$ is

6 the maximum RMS error value for the M spectra, RMSfreq(K_x) is the value
 7 corresponding to the number of N pixels that match the residual spectrum for the
 8 corresponding RMS error value for the M pixel, RMSfreq(min) is the number of
 9 occurrences of the least frequently occurring residual spectrum from the N pixel residual
 10 spectra, and RMSfreq(max) is the number of occurrences of the most frequently
 11 occurring residual spectrum from the N pixel residual spectra,

12
 13 $\text{Normval}(K_x) = \text{RMSval}(K_x) - \text{RMSval}(\min)$

14
 15
$$\frac{\text{RMSval}(\max) - \text{RMSval}(\min)}{\text{RMSval}(\max) - \text{RMSval}(\min)}$$

16
 17 $\text{Normfreq}(K_x) = \text{RMSfreq}(K_x) - \text{RMSfreq}(\min)$

18
 19
$$\frac{\text{RMSfreq}(\max) - \text{RMSfreq}(\min)}{\text{RMSfreq}(\max) - \text{RMSfreq}(\min)}$$

20
 21 $\text{wgtfactor}(K_x) = \text{sqrt}(\text{Normval}(K_x) * \text{Normfreq}(K_x)).$

22
 1 18. The process according to claim 10, wherein the step of comparing the
 2 corresponding residual spectrum of the M pixels, beginning with the M pixel having the
 3 highest RMS error value, to the residual spectra for the N pixels, to determine the
 4 frequency with which each of the corresponding residual spectra of the M pixels occurs
 5 within the residual spectrum for the N pixels utilizes at least one spectral matching
 6 algorithm.

1 19. The process according to claim 10, further comprising applying a shade mask to
 2 the unmixed pixels, such that only those of the N pixels not masked out are subject to the
 3 calculation of a root mean square error step.

1 20. The process according to claim 19, wherein the shade mask masks out the
 2 unmixed pixels comprised of greater than 80 percent shade.

- 1 21. The process according to claim 10, wherein the pre-selected baseline percentage
2 of reflectance is at most 1 percent.
- 1 22. The process according to claim 10, wherein the scene spectral data is
2 hyperspectral data.
- 1 23. The process according to claim 10, wherein the scene spectral data is
2 multispectral data.
- 1 24. The process according to claim 10, wherein the scene spectral data is ultraspectral
2 data.
- 1 25. The process according to claim 10, wherein the unmixing is linear.
- 1 26. The process according to claim 10, wherein the unmixing is non-linear.